CLAIMS

1. A process for manufacturing a zeolite membrane by hydrothermal synthesis on the surface of a porous tubular support with both ends open, which comprises:

adding a reaction solution containing a silica source and an alumina source and the porous tubular support into a lengthwise reaction container longer than the porous tubular support, while placing the porous tubular support vertically in the reaction container and substantially apart from the inner surface of the reaction container, and immersing the porous tubular support completely in the reaction solution so that the inside of the porous tubular support is filled with the reaction solution; and

heating the reaction solution under conditions of leaving the top and bottom ends of the porous tubular support open.

2. The process for manufacturing a zeolite membrane according to claim 1, wherein the porous tubular support is suspended in the reaction solution by a holding member located at the top of the reaction container.

3. The process for manufacturing a zeolite membrane according to claim 1 or 2, wherein the porous tubular support is placed on a holding member provided on the bottom of the reaction container, the holding member having a structure that does not substantially block the bottom of the porous tubular support.

4. The process for manufacturing a zeolite membrane according to one of claims 1 to 3, wherein the porous tubular support is added at one per the reaction container.

5. The process for manufacturing a zeolite membrane according to one of claims 1 to 4, wherein the reaction solution is heated in such a manner that the convection of the reaction solution occurs over the full length of the porous tubular support.

6. The process for manufacturing a zeolite membrane according to one of claims 1 to 5, wherein a jacket is provided on the periphery of the reaction container and the reaction solution is heated by feeding a heating medium to the jacket.

7. The process for manufacturing a zeolite membrane according to one of claims 1 to 6, wherein the level of the reaction solution is 2 to 30 cm above the top of the porous tubular support placed.

8. The process for manufacturing a zeolite membrane according to one of claims 1 to 7, wherein the distance from the inner surface of the reaction container to the outer surface of the porous tubular support placed is 2 to 25 mm.

9. The process for manufacturing a zeolite membrane according to one of claims 1 to 8, wherein a transparent solution with a turbidity of 300 NTU or less is prepared as the reaction solution and the temperature at which the transparent solution is heated is adjusted to a temperature of lower than Tb and not lower than (Tb - 50°C), wherein Tb is the boiling temperature of the transparent solution.

10. The process for manufacturing a zeolite membrane according to claim 9, wherein the transparent solution is added into the reaction container at lower than 35°C and heated at a rate of 5 to 100°C/min.

11. The process for manufacturing a zeolite membrane according to one of claims 1 to 8, wherein the reaction solution is provided as a suspension and the suspension is boiled.

12. The process for manufacturing a zeolite membrane according to claim 11, wherein the suspension is added into the reaction container at lower than 35°C and heated at a rate of 5 to 100°C/min up to around its boiling temperature and kept at around the boiling temperature.

13. An apparatus for manufacturing a zeolite membrane by hydrothermal synthesis on the surface of a porous tubular support with both ends open, which comprises:

(a) a reaction container which is longer than the porous tubular support, and accommodates a reaction solution containing a silica source and an alumina source and the porous tubular support;

(b) a heating device which surrounds the porous tubular support; and

(c) a holding device which holds the porous tubular support vertically in the reaction container, whereby the porous tubular support is completely immersed in the reaction solution and substantially apart from the inner surface of the reaction container;

wherein the heating device being used for heating the reaction

solution to form a zeolite membrane on the surface of the porous tubular support.

14. The apparatus for manufacturing a zeolite membrane according to claim 13, wherein the holding device is a member on which the porous tubular support is placed and has such a structure that does not substantially block the bottom opening of the porous tubular support.

15. The apparatus for manufacturing a zeolite membrane according to claim 13 or 14, wherein the distance from the inner surface of the reaction container to the outer surface of the porous tubular support placed is 2 to 25 mm.

16. The apparatus for manufacturing a zeolite membrane according to one of claims 13 to 15, wherein the height of the reaction container is larger than the length of the porous tubular support by 4 to 90 cm.

17. A zeolite tubular separation membrane comprising a porous tubular support with both ends open and a zeolite membrane formed on the surface of the porous tubular support, wherein 80% or more of the zeolite membrane is formed within 0.1 to 20 μm from the outer surface of the porous tubular support and substantially no zeolite membrane is formed on the inner surface of the porous tubular support.

18. A zeolite tubular separation membrane comprising a porous tubular support with both ends open and a zeolite membrane which comprises a plurality of zeolite single crystals and is formed on the surface of the porous tubular

support, wherein the zeolite single crystals exposed on the surface of the zeolite membrane each have a growth axis almost perpendicular to the porous tubular support.

19. The zeolite tubular separation membrane according to claim 18, wherein the membrane has grain boundary layers in the spaces among the plurality of zeolite single crystals.

20. The zeolite tubular separation membrane according to claim 19, wherein the grain boundary layers are 2 to 50 nm in thickness.

21. The zeolite tubular separation membrane according to claims 17 to 20, wherein a separation factor α is 1000 or more when the separation membrane is used to separate water from a mixture of the water and alcohol.

22. The zeolite tubular separation membrane according to claim 21, wherein the separation factor α is 10000 or more.

23. The zeolite tubular separation membrane according to claims 17 to 22, wherein the porous tubular support is a porous ceramic tube.